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Rural Science Teachers Collaborative Design and Iterative Implementation of Three-Dimensional Lessons

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Abstract: Rural high school science teachers often work in isolation with fewer collaborative and professional learning opportunities. One opportunity they have missed is deep learning about and how to implement three-dimensional science lessons. To bridge the geographic isolation of these teachers and increase their capacity with three-dimensional science, we developed a novel professional learning model called Technology-Mediated Lesson Study (TMLS). This engages teachers in iterative, collaborative cycles of lesson design, teaching, observations via technology, and lesson redesign with a team of colleagues aimed at high-impact professional learning and enactment. This paper presents the program design and activities with science teachers who collaboratively design and implement lessons using the TMLS model.

Introduction

A major challenge for secondary science teachers in rural schools is isolation: being the only science teacher in the school or the only teacher of a particular subject. As a result, rural science teachers have fewer or no opportunities for meaningful collaboration, even though collaboration is a key characteristic of effective professional learning. When professional learning is up-to-date, ongoing, collaborative, practice-based, and connected to local contexts (Kennedy, 2016; Desimone, 2009; Penuel et al., 2007) it is more effective at changing teaching practice. Lesson Study is an established professional learning model that has shown success (Cheung & Wong, 2014; Kanellopoulou & Darra, 2019) in meeting teachers' professional learning needs by improving collaboration, helping them examine their practice, and enhancing student learning.

In one western state in the United States, rural schools are organized around four regional education service centers in which participating school districts collaborate to improve instruction in their region. These regional service centers provide professional development in broadly applicable categories such as educational technology but lack the resources to support science-specific professional learning and enactment. In this state, new secondary science standards are being implemented in the schools. These standards are built from the National Research Council's A Framework for K-12 Science Education (NRC, 2012) that established the foundation for the Next Generation Science Standards. The new state standards are similar, also using three-dimensional learning, combining science practices, crosscutting concepts, and disciplinary core ideas.

Many of the urban districts in the state are already training high school science teachers in three-dimensional science teaching, while most rural teachers have not received any training on the new standards. The program described here is designed to address the lack of professional learning opportunities for rural science teachers by using technology to bridge the geographic isolation they experience. Building from lesson study (Lewis & Hurd, 2011), we developed a novel professional learning model called Technology-Mediated Lesson Study (TMLS). TMLS engages teachers in iterative, collaborative cycles of lesson design, enactment, observation via technology, and lesson redesign with a team of colleagues from their region, resulting in high-impact professional learning and enactment. Improved science teaching in these regions will provide equitable access to high-quality science for all students who live in the rural regions of the state, many of whom are economically disadvantaged.

The purpose of this paper is to present the program and collaborative design and enactment using TMLS with rural science teachers. Initially, a small cohort of teachers engaged in collaborative codesign activities building shared capacity around the three-dimensional science standards, developing professional learning materials and experiences for other rural science teachers, and enactment of newly designed lessons through technology-mediated lesson study. This cohort of teachers then worked with more teachers to engage in building their capacity with three-dimensional science and the TMLS process.

Lesson study

Originating in Japan, lesson study is an instructional inquiry model that involves a group of educators organizing together under shared goals focused on student learning and co-creating lessons to meet those goals (Lewis & Hurd, 2011). Four essential teaching tasks—designing lessons, teaching, observing and analyzing student responses, and reflecting on implications for future lessons—are all foci of the lesson study process (McDougal, 2022). Lesson study slows down the lesson creation process, allowing teachers to concentrate on critical elements, such as the planning and reflection stage, to which they may not otherwise devote significant time. They are also given opportunities to observe another teacher's lesson—an opportunity that, for many teachers, is not frequently available. Watching someone else teach allows the observers to focus on student learning and misconceptions, which teachers can miss while teaching due to divided focus across an entire class. This close observation can help the teachers think about the design process and how to improve the lesson so misconceptions can be addressed. The repeated steps of lesson study develop educators' knowledge and motivation for teaching and helps develop a robust professional learning community (Lewis & Hurd, 2011; Murata, 2011).

Technology-mediated lesson study

One of the practical difficulties of lesson study is accommodating teacher schedules so they can fully participate in a lesson study group (Choppin et al., 2020; Huang, 2020; Soto et al., 2019). For rural teachers it can be almost impossible to meet with other teachers in the same discipline as they are often at other schools a considerable distance away. Technology-Mediated Lesson Study (TMLS) utilizes technology resources to allow teachers to interact and learn together when not co-located. This interaction among remotely isolated teachers connects them with colleagues they otherwise would have no connection with, including those in other districts. In TMLS, teachers initially gather as a group, set a goal or purpose of the group; which might be learning something new about teaching and learning or new curriculum writing. They then collaboratively work on the aim of their group (e.g., writing a lesson plan). Taking turns, they implement in their classroom where they record the enactment and share it with their group. The implementing teacher reflects, and the other teachers comment on the enactment. Then they meet virtually where they discuss and revise, ready for the next teachers to implement with the updated materials.

Primary goals of the program

This program has three goals. First, principles: an innovative model for rural science teacher professional development via technology-mediated lesson study that supports translating professional learning into classroom practice through social support systems among rural teachers. Second, people: building expertise and capacity among the rural science teachers to support three-dimensional science teaching. Third, products: creating and disseminating high-quality three-dimensional science lesson plans aligned with the new state standards and the Next-Generation Science Standards that will be shared with teachers in the state and across the country.

Conceptual framework

The design and research activities of this work are built on an ecological model described by Sallis et al. (2008) for changing health behaviors and is applied to changing teaching practices to incorporate three-dimensional science teaching. Teachers choose instructional practices based on personal factors (e.g., attitudes, self-efficacy), social factors (e.g., peer, administrator, and student expectations), and contextual factors (e.g., physical, material, and time resources). The program targets personal factors by supporting rural science teachers' development of knowledge, self-efficacy, and positive attitudes about three-dimensional science teaching. Social factors via cohorts of subject-region teams provide a sense of community and support for the instructional changes needed for the new state standards.

Design and implementation activities

Design activities in this program are facilitated by the teachers and supported by the researchers. In the first year five researchers and four teachers, from the four rural regions of the state, met five times in-person in two-day workshops to learn more about three-dimensional science, design a three-dimensional lesson, implement the lesson, and engage in the technology-mediated lesson study process. In the beginning a shared knowledge of three-dimensional science was needed, and through different activities this shared understanding began to grow. Once a strong base of understanding was established, a lesson was designed. This collaborative process among the teachers required understanding of their different contexts within the rural settings. Some teachers were very geographically isolated, were the only science teacher at their school, or taught a variety of students with different needs, including academic and socio-economic challenges. This caused some complexities in the design of the

lesson. This included, but was not limited to, selecting a phenomenon, finding the best examples to use in the lesson that would be understandable by all their students, and teacher preferences with the format of a lesson plan. The teachers knew that many areas of the lesson would be improved through the enactment and technology-mediated lesson study (TMLS) process.

Using TMLS, the teachers implemented their initial three-dimensional lesson plan. In this process, one teacher implemented the lesson and recorded it using a Swivl. After uploading the recording and providing some initial reflections on the enactment, the other teachers watched the recording and commented with questions, praise, and ideas for improvement. Then they meet as a group in Zoom to reflect and discuss the enactment and make changes to the lesson. Then, another teacher would implement the lesson and the whole process was repeated. After each of the teachers implemented the lesson a final design on the lesson was completed. The teachers assessed the lesson plan using the EQUIP rubric.

After the first year and small cohort of teachers, they collaborated with the researchers in designing a summer workshop for nine additional rural science teachers. This workshop introduced additional teachers to three-dimensional science and the TMLS process. The summer workshop was five days and in small groups, facilitated by the first cohort of teachers, a new science lesson was designed. In the first few months of the school year these three groups of teachers engaged in the TMLS process and iteratively redesigned and implemented their lessons. During the 2022-2023 school year, these teacher groups designed and implemented a total of four lessons per group (total of 12 lessons) aligned to three-dimensional science. Each group used the TMLS process as they refined their lesson plan.

What we have learned

We have learned that the teachers appreciate the process of collaborating together. Since the majority of them are quite isolated, they enjoy working together and focusing on three-dimensional science lessons (devoid of any school issues). It is pure design focused on the science. They enjoy the TMLS process because the technology provides a means for further collaboration and engagement together, but also because it has iteratively improved their lessons. They have improved their collaboration skills and made new connections. One teacher said, “It’s so nice having other people…who have different strengths but then also different perspectives. They’re going to notice things I don’t notice. And it’s so nice having a group that is very focused on creating content and not dealing with school drama. There’s not external education problems. We’re just creating content.”

They have enjoyed observing each other teach. Many of these rural teachers do not have the opportunity to observe other science teachers as some are the only one in their building (or even district). They do not always like watching themselves teach, but they are learning from each other beyond the intent of this work. Many of the teachers expressed how surprised they were by how much they learned through the TMLS process. One teacher mentioned, “This has been the best professional development I’ve been involved in. Because of [other group members,] I can see the value in what we are doing. I can see the advantage of having three or four teachers in the same subject in a school.” Another teacher said, “You go to a [professional development] meeting, they tell you what you’re going to do and then you don’t get the time to practice it, so you just kind of fall back into the same rhythm that you were in before. Whereas this [TMLS] model has been that they told us what was expected and then we had time to practice it. And then when it wasn’t right, we had time to fix it and then have more time to fix it until it was to where we were happy.”

They enjoy learning about and how to implement three-dimensional science. It is exciting for them to engage together, but more to observe changes in their students. They have observed engagement, motivation, and questioning/language changes with just one implementation of a three-dimensional science lesson. The large amount of time to collaboratively design and iteratively implement and redesign a lesson is worth the changes they see in their students. In changing about how they think about three-dimensional science now one teacher said, “The DCIs, the SEPs, and the CCs are now things that are conscious on my mind when I am planning a lesson; whether I implement every single one, every single lesson is another story. But they’re in my mind, and I do my best to implement at least a couple of those things into each of the lessons I plan.”

We have learned that group dynamics is a complex system and often is quite delicate too. Becoming close to each other, understanding each other, and learning how to work together are important elements to make the design and TMLS process successful. Each of the groups have been facilitated slightly differently by the first-year cohort teacher, but each group has made progress throughout the TMLS process. The program is an iterative process of learning and growing individually and as a group. Keeping our eyes on the purpose is important, that helps everyone remember their roles and responsibilities in the process.

What others can learn

Others can learn from our design and implementation activities. There are a lot of programs that target three-dimensional science, but not many focused in rural high school science teachers. Learning about who they are connected to and how to help them connect is important. We have learned that technology is a powerful tool that can be utilized in our favor. Technology can connect people and can be used for design and observation activities. With that, lesson study is a powerful tool for connecting teachers and designing and implementing lessons. Even teachers who are not isolated could find ways to use technology and technology-mediated lesson study in positive ways.

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